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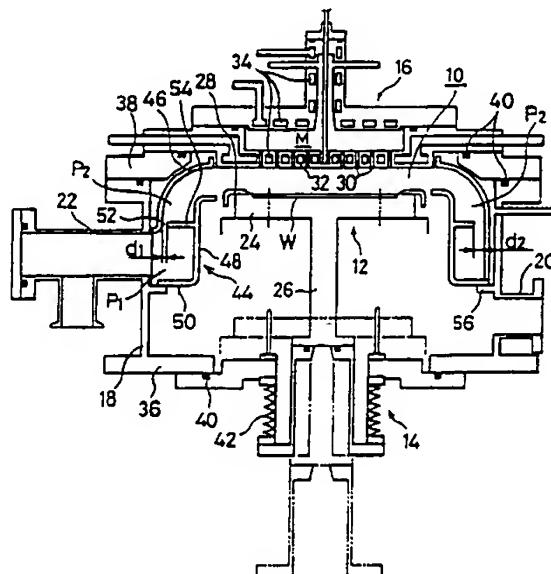
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### (54) Thin-film deposition apparatus

(57) A compact thin-film deposition apparatus can promote a stable growth of a high quality thin-film product of uniform quality. It comprises a vacuum-tight deposition chamber (10) enclosing a substrate holding device (12) for holding a substrate (W). An elevator device (14) for moving the substrate holding device and a gas showering head (16) for flowing a film forming gas towards the substrate are provided. A transport opening (20) and an exhaust opening (22) are provided on a wall section (18) of the deposition chamber at a height to correspond to the transport position and the deposition position respectively. The deposition chamber is provided with a flow guiding member (44), and the flow guiding member comprises a cylindrical member (48) to surround an elevating path of the substrate holding device and a first ring member (50) to vertically divide a chamber space at a height between the exhaust opening and the transport opening.

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## Description

## BACKGROUND OF THE INVENTION

## Field of the Invention

[0001] The present invention relates in general to a chemical vapor deposition (CVD) apparatus for depositing thin-films, in a vapor phase reaction, of a highly dielectric or ferroelectric substance such as barium/strontium titanate on a substrate such as a semiconductor wafer.

## Description of the Related Art

[0002] In recent years, there has been a quantum jump in circuit density of integrated circuit devices produced by the semiconductor industries, and intense development activities are underway in anticipation of giga-bit order DRAMs replacing the prevailing mega-bit order DRAMs of today. Dielectric thin-film materials used to make high capacitance devices necessary for producing DRAMs have, in the past, included silicon oxide or silicon nitride films of dielectric constant less than 10, tantalum pentoxide ( $Ta_2O_5$ ) films of dielectric constant less than 20; however, newer materials such as barium titanate ( $BaTiO_3$ ) or strontium titanate ( $SrTiO_3$ ) or barium/strontium titanate ( $(Ba, Sr)TiO_3$ ) appear to be more promising.

[0003] When growing such a metal oxide thin-film on a substrate in a vapor phase chemical reaction, the substrate is placed on a susceptor disposed in a vacuum-tight film deposition chamber, and the substrate is heated, by such means as a heater enclosed in the susceptor, to a specific temperature, and a mixture of a feed gas and a reactant gas (oxygen-containing) is ejected to the substrate through a gas showering head.

[0004] To produce a thin-film of a uniform quality using such a method, a careful consideration must be given to managing the process of flowing the gaseous mixture over the substrate, which means that not only the routing pattern from the gas showering head to the substrate but also the overall process of flow including the effect of the spent gas exhaust path in the film deposition chamber become important parameters.

[0005] For example, it may seem desirable to place a spent gas exhaust opening directly below the pedestal so as to form an axisymmetric pattern of flow of a film forming gas enveloping the substrate, however, such an arrangement is not only difficult to do, because of the presence of other components such as pedestal support shaft and elevating device therefor, but it increases the length of the flow path within the chamber, leading to a problem of precipitation and adhesion of reaction products, that could become a potential source of contamination in the deposited films. On the other hand, an arrangement may be considered in which a plurality of exhaust openings are provided symmetrically around

the outer periphery of the substrate holder to produce a symmetrical flow pattern of a film forming gas over the substrate, but such a design would lead to an expanded apparatus requiring a large floor space, and also would lead to a difficulty of mechanical interference with exhaust opening and substrate transport exit opening.

[0006] Therefore, it is a first object of the present invention to provide a compact thin-film deposition apparatus which promotes a stable growth of a high quality thin-film product of uniform quality.

[0007] Furthermore, one of the characteristics of a feed material is that after the feed liquid is vaporized, the range of stability of the feed vapors is extremely narrow such that the vapors are condensed when the ambient temperature is low while the vapors are decomposed when the ambient temperature is high. The present inventors had proposed a method, in a Japanese Patent Application, Laid-Open Publication, H9-2896, to counter the difficulties posed by such a narrow stability range of vapors by controlling the inner wall temperature of the deposition chamber at a certain temperature close to the vaporization temperature. It has been found that, although it is possible to effectively suppress the formation of reaction products, such products cannot be eliminated completely such that fine particles are produced and become attached to the inner walls of the deposition chamber.

[0008] In the course of conducting thermal analyses of the feed materials, it was found that precursors of each liquid feed materials for BST or SBT, for example, do not have a complete and clear temperature range where all three materials can remain in a stable gaseous state, resulting in condensation or decomposition of at least a portion of the feed vapor. It was also discovered that condensed and adhered products are easy to wash off when compared with decomposed and adhered products.

[0009] It is, therefore, a second object of the present invention to provide a deposition apparatus which produces a high quality and uniform thin-film product while enabling to avoid decomposition of the feed vapor at high temperatures.

## SUMMARY OF THE INVENTION

[0010] The first object outlined above has been achieved by a thin-film deposition apparatus comprising: a vacuum-tight deposition chamber enclosing a substrate holding device for holding a substrate; an elevator device to raise or lower the substrate holding device between a deposition position and a transport position; a gas showering head for flowing a film forming gas towards the substrate; a transport opening provided on a wall section of the deposition chamber at a height to correspond to the transport position; and an exhaust opening provided on the wall section at a height between the deposition position and the transport position, wherein the deposition chamber is provided with a

flow guiding member, the flow guiding member comprising a cylindrical member to surround an elevating path of the substrate holding device, and a first ring member to vertically divide a chamber space at a height between the exhaust opening and the transport opening.

[0011] Accordingly, by dividing the chamber space into two spaces where one is for thin film deposition process and the other is a working space for such as delivery of the substrate, the gas flow is effectively controlled to provide a stable deposition condition. Further, by forming an annular flow path to guide a spent gas to the exhaust gas opening by the flow guiding member, non-uniform flow of film forming gas over the substrate due to an uneven arrangement of an exhaust opening is minimized; thereby providing a thin-film product of highly uniform quality by a compact design apparatus.

[0012] In the apparatus presented above, an outer flow guiding member may be disposed between the flow guiding member and an inner surface of the wall section to form an exhaust passage for a spent gases in association with the flow guiding member. It is advantageous to provide the flow guiding member and the outer flow guiding member easily removable from the deposition chamber.

[0013] In the apparatus presented above, a second ring member may be disposed above the first ring member covering the annular flow path so as to form a circumferential slit channel for communicating the chamber space with said annular flow path. The first ring member may be formed to extend from the flow guiding member. The circumferential slit channel may be shaped in such a way that a slit width in a vicinity of the exhaust opening is narrower than a slit width remote from the exhaust opening. There may be only one exhaust opening in a circumferential direction.

[0014] A flow adjusting ring may be placed on the second ring member so that the slit size can be adjusted to produce a uniform flow over the substrate. The outer flow guiding member may be shaped in a curved shape following the configuration of an inner surface of the deposition chamber. The material for the flow guiding member may be made of quartz or metals such as stainless steels and aluminum.

[0015] A cylindrical wall member surrounding the substrate holding device may be provided, and the flow guiding member may be provided on an outer circumference of the cylindrical wall member. The cylindrical wall member may comprise an insulator member for suppressing radiation heat from the substrate holding device, and it may be provided with a temperature control device to control the cylindrical wall member at a specific temperature. The temperature control device may be provided with a thermal medium passage formed within the cylindrical wall member and an external thermal medium supply apparatus to supply a thermal medium at a controlled temperature.

[0016] In another aspect of the invention, a thin-film deposition apparatus comprises: a cylindrical vacuum-

tight deposition chamber enclosing a substrate holding/heating device; an elevator device to raise or lower the substrate holding/heating device between a deposition position and a transport position; a gas showering head for flowing a film forming gas from a top of the deposition chamber towards the substrate; a transport opening provided on a wall section of the deposition chamber at a height to correspond to the transport position; and an exhaust opening provided on a wall section of the deposition chamber at a height between the deposition position and the transport position, wherein a cylindrical thermal insulator member is disposed to surround the substrate holding/heating device placed at the deposition position.

[0017] Accordingly, the thermal insulator member suppresses radiation heat from the substrate holding/heating device, and prevents the interior of the deposition chamber to reach a temperature above the decomposition temperature of the feed material. Therefore, the feed material is prevented from decomposing and sticking by coming into contact with hot regions. If the feed material does condense on interior regions, it can be washed off and the apparatus operation can be resumed. It is preferable to make the insulator from thermal insulating materials such as quartz, stainless steels and ceramics.

[0018] The thermal insulator member may be provided with a temperature control device for controlling the thermal insulator member at a predetermined temperature. The temperature control device may be constructed with a thermal medium passage formed inside the insulator and an external thermal medium supply device to supply a medium at a controlled temperature.

[0019] The thermal insulator member may be disposed in the deposition chamber in a detachable manner. The apparatus may be provided with a cooling device to cool the wall section of the deposition temperature to a temperature lower than a specific temperature. The apparatus may be provided with a cooling device to cool the wall section of the deposition chamber to a temperature lower than a predetermined temperature.

[0020] In another aspect of the invention, a thin-film deposition apparatus comprises: a cylindrical vacuum-tight deposition chamber enclosing a substrate holding device for holding a substrate; an elevator device to raise or lower the substrate holding device between a deposition position and a transport position; a gas showering head having a nozzle plate for flowing a film forming gas from a top of the deposition chamber towards the substrate; a transport opening provided on a wall section of the deposition chamber to correspond to a height of the transport position; and an exhaust opening provided on the wall section at a height between the deposition position and the transport position, wherein the exhaust opening is formed substantially in one circumferential location, and a center of gas flow density of a gas flowing out of the gas showering

head is offset from a center of the substrate held on the substrate holding device horizontally in a direction opposite to the exhaust opening.

[0021] Accordingly, non-uniform gas flow density of film forming gas over the substrate due to an uneven arrangement of an exhaust opening is compensated, thereby providing a thin-film product of highly uniform thickness by a compact design apparatus.

[0022] It can be done by arranging a center of a nozzle region of the nozzle plate offset from a center of the substrate held on the substrate holding device horizontally in a direction opposite to the exhaust opening, or by making a nozzle hole distribution where a larger number of nozzle holes are provided on the opposite side of the exhaust opening than the other.

[0023] It is recommendable to provide the gas showering head with a temperature control device for controlling the nozzle plate at a predetermined temperature by using a thermal medium. The nozzle plate may be provided with a nozzle area larger than the substrate.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

Figure 1A is a cross sectional view of a first embodiment of the thin-film deposition chamber of the present invention;

Figure 1B is a cross sectional view of a minor modification of the first embodiment of the thin-film deposition chamber of the present invention;

Figure 2 is a cross sectional view of a second embodiment of the thin-film deposition chamber of the present invention;

Figure 3 is cross sectional view of a third embodiment of the thin-film deposition chamber of the present invention;

Figure 4 is cross sectional view of a fourth embodiment of the thin-film deposition chamber of the present invention;

Figure 5 is cross sectional view of a fifth embodiment of the thin-film deposition chamber of the present invention;

Figure 6 is cross sectional view of a sixth embodiment of the thin-film deposition chamber of the present invention;

Figure 7 is a cross sectional view of a seventh embodiment of the thin-film deposition chamber of the present invention;

Figures 8A and 8B are partial plan views of eighth and ninth embodiments of the thin-film deposition chamber of the present invention; and

Figures 9A and 9B are partial plan views of tenth and eleventh embodiments of the thin-film deposition chamber of the present invention.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] Figure 1A shows a first embodiment of the thin-film deposition apparatus comprised by a vacuum-tight deposition chamber 10 of an overall cylindrical shape including: a substrate holder 12 for holding a substrate W; an elevator device 14 for raising or lowering the holder 12 between a deposition position close to the upper limit and a transport position close to the lower limit; a gas showering head 16 for flowing feed gas towards the substrate W from the top of the deposition chamber 10; a transport opening 20 formed on a wall section 18 of the deposition chamber 10 at a height to correspond with the transport position; and an exhaust opening 22 formed on the wall section 18 of the deposition chamber 10 at a height between the deposition position height and the transport position height. One exhaust opening 22 and one transport opening 20 are provided separately at suitable circumferential positions.

[0026] The substrate holder 12 is comprised by a circular disk shaped susceptor 24 having an internal heater (not shown) and a support rod 26 to connect to the elevator device 14. The outer peripheral edge of the susceptor 24 has an annular deposit-blocking plate 28 of an L-shape cross section to prevent deposition of reaction products. The gas showering head 16 has a nozzle plate 32 of a circular shape and a size slightly larger than the substrate W, and numerous nozzle holes 30 are evenly distributed at a nozzle region 33 which is a central area excepting a narrow peripheral region of the nozzle plate 32. Also, in this case, the deposition chamber 10 is provided with a mixing space for mixing the feed gas with the reactant gas (oxidizing gas for example), and a jacket heater (temperature control device) 34 for maintaining the nozzle holes 30 and the mixing space at a certain temperature.

[0027] The deposition chamber 10 is comprised by: a cylindrical wall section 18; a bottom plate 36 having a central opening section for receiving the elevator device 14; a gas showering head 16 serving also as the ceiling for the chamber 10; and a tapered block 38 fitting between the wall section 18 and the gas showering head 16 to constitute a taper section. It includes other components such as O-rings 40 as seals and bellows 42 where necessary, and gates (not shown) for shutting the transport opening 20. In this embodiment, temperature control device in the form of thermal medium passages are not provided on the side wall section 18 and the bottom plate 36.

[0028] The deposition chamber 10 is provided with two flow guiding plates 44, 46 to form passages P1, P2 to guide the spent exhaust gas to the exhaust opening 22. Passage P1 is comprised by: an inner flow guiding plate 44; a cylindrical member 48 surrounding the elevating path for the substrate holder 12; a first ring member 50 to divide the chamber space vertically at a height

between the exhaust opening 22 and the transport opening 20; and a second ring member 54 having an annular slit to form a slit channel 52 communicating throughout the outer flow guiding plate 46. The outer flow guiding plate 46 is formed along the inside wall of the deposition chamber 10 and forms an exhaust passage P2 by pairing with the inner flow guiding plate 44 to guide the reacted gas to the exhaust opening 22.

[0029] The slit channel 52 is for preventing uneven flow of gas caused by the fact that there is only one exhaust opening 22, and is designed so that the slit width becomes narrower as it approaches the exhaust opening 22. In other words, the slit width  $d_1$  at the exhaust opening 21 is the minimum and slit width  $d_2$  at the opposite end is the maximum. The top end of the inner flow guiding plate 44 extends inward, and performs a function of narrowing the space between the susceptor 24 in conjunction with the deposit-blocking plate 28. The inner and outer flow guiding plates 44, 46 are seated on an annular protrusion section 56 without any fixing means. Therefore, the flow guiding plates 44, 46 can easily be removed from the deposition chamber 10 for cleaning and exchanging purposes just by picking up after removing the gas showering head 16 at the top and the taper block 38.

[0030] The operation of the thin-film deposition apparatus so constructed will be explained. The susceptor 24 is placed in the transport position, shown by a double-dotted line in Figure 1A, and a substrate W is loaded thereon from the transport opening 20 by a robot hand (not shown), and the substrate W is raised by the elevator device 14 to the deposition position shown by a solid line in Figure 1A. The substrate W is heated using the susceptor 24 to a deposition temperature, and a gaseous mixture of feed gas and reactant gas is supplied from the gas showering head 16 which is kept at a specific temperature by means of a circulating thermal medium.

[0031] The feed gas and the reactant gas are reacted on the substrate W to form a thin-film deposit on the substrate W, and the spent gas is directed radially over the substrate W to flow into the exhaust passage P2 formed by the inner and outer flow guiding plates 44, 46. Spent gas continues to be exhausted through the slit channel 52 into the annular flow passage P1, and is removed from the exhaust opening 22. Even though there is only one exhaust opening, because the slit width of the slit channel 52 becomes narrower towards the exhaust opening 22, uniform radial flow is generated all around the circumference of the substrate W, thereby producing a deposit of uniform quality in radial as well as circumferential directions on the substrate W.

[0032] Also, because of the presence of the inner flow guiding plate 44, the flow path of the reactant gas is restricted so that it is difficult for the gas to reach the back of the susceptor 24 and the bottom portions of the elevator device 14. Therefore, adhesion of reaction products and a potential source of contamination due to

such products are prevented. If the feed material and reaction products become adhered to the flow guiding plates 44, 46, they can be removed and exchanged with new ones by stopping the operation and removing the gas showering head 16 at the top of the deposition chamber 10 and the taper block 38, so that the operation can be resumed.

[0033] Figure 1B has a similar construction with the embodiment described above, where the outer flow guiding plate 46 is omitted.

[0034] Figure 2 shows a second embodiment of the deposition apparatus. In this embodiment, the second ring member 54 of the inner flow guiding plate 44 is separated at a uniform distance from the outer flow guiding plate 46, but there is provided a flow adjusting ring 58 on top of the second ring member 54 so as to enable the clearance  $d_1$  at the exhaust opening 22 and the clearance  $d_2$  at the opposite end to be in a relation  $d_1 < d_2$ . Uniform flow of gas, to suit the operating conditions, can be produced by adjusting the shape of the flow adjusting ring 58 or by placing the flow adjusting ring 58 eccentrically on the second ring member 54. Also, in this case, a cylindrical thermal insulator 60 is provided between the inner flow guiding plate 44 and the susceptor 24 so as to prevent a temperature increase of the flow guiding plates 44, 46 by radiation from the susceptor 24.

[0035] Figure 3 shows a third embodiment of the deposition apparatus. In this embodiment, the insulator 60 has an internal fluid passage 62 for flowing a thermal medium. A thermal medium is supplied from an external supply source by connecting a supply pipe 64 and a return pipe to the insulator 60. The performance of the flow guiding plates 44, 46 is improved further by this arrangement of absorbing the radiation in the thermal cooling medium so that the deposition chamber temperature can be optimized.

[0036] Figure 4 shows a fourth embodiment of the thin-film deposition apparatus. The deposition chamber 10 in this apparatus does not have flow guiding plates but a thermal insulator member 74 surrounding the elevator path for the substrate holder 12 is provided. Thermal insulator member 74 is made of such materials as quartz, stainless steels and ceramics and is formed integrally with an annular base 76 which extends out at the base section. The insulator member 74 is disposed inside the deposition chamber 10 by seating it on an annular protrusion 78 which is formed on the wall section 18 below the exhaust opening but above the transport opening. Therefore, it can be removed readily from the deposition chamber 10 by removing the gas showering head 16 at the top and the taper block 38.

[0037] The operation of the deposition apparatus so constructed will be explained. The susceptor 24 is placed in the transport position, shown by a double-dotted line in Figure 4, and a substrate W is loaded thereon from the transport opening 20, and the substrate W is raised by the elevator device 14 to the deposition posi-

tion shown in Figure 4. The substrate W is heated using the susceptor 24 to a deposition temperature, and a gaseous mixture of feed gas and reactant gas is ejected from the gas showering head 16, which is kept at a specific temperature by means of a circulating thermal medium, towards the substrate W.

[0038] The feed gas and the reactant gas are reacted on the substrate W to form a deposit on the substrate W, and the spent gas is directed radially over the substrate W to flow into the exhaust passage P formed by wall section 18 of the chamber 10 and the annular insulator member 74, and is exhausted from the exhaust opening 22. The passage of the reacted gas is restricted by the insulator member 74 and the annular base 76 so that gas flow to the back of the susceptor 24 and to the elevator device 14 and other regions disposed below the chamber 10 is made difficult, thereby preventing particle adherence and possible source of contamination caused by such particles.

[0039] During the film forming reaction, the insulator member 74 suppresses radiation from the substrate holder 12 to prevent the wall section 18 of the chamber 10 to be heated above the decomposition temperature of the feed material, thereby preventing the feed material to decompose and stick to these places. When condensation of the feed material does occur in such places, the gas showering head 16 and the taper block 38 can be removed through the top of the chamber 10 so that the interior of the chamber 10 can be washed before resuming the deposition process.

[0040] Figure 5 shows a fifth embodiment of the thin-film deposition apparatus. The insulator member 74 is a simple cylindrical member and is detachably seated on an annular groove 82 provided on the inner surface of the wall section 18. In this embodiment, because the shape is made simpler and more compact than the previous insulator ring so that not only manufacturing of the insulator member 74 is easy but removal and exchange steps become much easier. This is especially desirable when it is necessary to change the material that the insulator member 74 is made of to suit the film deposition process.

[0041] Figure 6 shows a sixth embodiment of the deposition apparatus. In this case, a thermal medium passage 84, for flowing a thermal medium such as oil, is provided inside the insulator member 74. A thermal medium is supplied from an external supply source by connecting a supply pipe 86 and a return pipe to the insulator 74. The ability to control temperature rise in the wall section 18 is further improved because of the absorption of the radiation from the interior of the deposition chamber 10.

[0042] Figure 7 shows a seventh embodiment of the thin-film deposition apparatus. In this case, heating of the wall section 18 and the elevator flange 90, fixed to the bottom plate 36, by radiation from the substrate holder 12 is prevented by providing a jacket 88 for cooling the wall section 18, and a jacket 89 for cooling the

5 elevator flange 90. In addition to the thermal barrier effects provided by the insulator member 74, these provisions further assure the interior temperature of the chamber 10 to be maintained lower than the deposition reaction temperature. Such measures ultimately provide improved life of sealing members and consequently the safety of workers.

[0043] Figures 8A, 8B show eighth and ninth embodiments of the thin-film deposition apparatus. In the case 10 shown in Figure 8A, the center of the nozzle plate 32 of the gas showering head 16 is offset by  $e_1$  from the center of the substrate W held on the susceptor 24 towards the exhaust opening 22. This arrangement can be used in conjunction with any of the apparatuses 15 shown in Figures 1 to 7. In the case shown in Figure 8A, the nozzle plate 32 has a larger radius R than the substrate W, and in the case shown in Figure 8B, the nozzle plate 32 has a flat oval shape having two semicircles of a radius R with an offset by a distance  $e_2$ . The size of 20 offsets  $e_1$ ,  $e_2$  should be chosen to suit the processing conditions so that uneven gas flow caused by asymmetrical location of the exhaust opening 22 is compensated by such offset of the nozzle plate 32. In all cases, the substrate W must reside within the shadow cast by the 25 nozzle plate 32.

[0044] Figure 9A shows a tenth embodiment of the thin-film deposition apparatus. In this case, the distribution pattern of the nozzle holes 30 in the nozzle region 33 is altered in a half-side close to the exhaust opening 30 22 compared with the opposite half-side. Because only one exhaust opening 22 is provided to the chamber 10, a flow heading towards the exhaust opening 22 is developed on the substrate W. Therefore, if the distribution pattern of the nozzle holes 30 is designed symmetric, 35 the gas flow density on the substrate W will become higher in the exhaust opening side than the opposite side. Thus, a larger number of gas ejection holes 30 are provided on the opposite half-side in the nozzle region 33 than on the exhaust opening half-side to equalize the 40 gas flow density at both sides of the nozzle region 33. This type of gas ejection nozzle 16 can be used with any one of the apparatuses shown in Figures 1 to 7.

[0045] Figure 9B shows an eleventh embodiment of the thin-film deposition apparatus, where the area of the 45 nozzle region 33 is altered in a half-side close to the exhaust opening 22 compared with the opposite half-side. That is, the nozzle region 33 has a radius  $R_1$  larger than the radius  $r$  of the substrate W on the exhaust opening half-side, and a radius  $R_2$  larger than the radius 50  $R_1$  on the opposite half-side. This feature also works for equalization of the gas flow density over the nozzle region 33. It also can be used with any one of the apparatuses shown in Figures 1 to 7.

[0046] According to its broadest aspect the invention 55 relates to a thin-film deposition apparatus comprising: a vacuum-tight deposition chamber enclosing a substrate holding device for holding a substrate; an elevator device to raise or lower said substrate holding device

between a deposition position and a transport position; and a gas showering head for flowing a film forming gas towards said substrate.

[0047] It should be noted that the objects and advantages of the invention may be attained by means of any compatible combination(s) particularly pointed out in the items of the following summary of the invention and the appended claims.

#### SUMMARY OF THE INVENTION

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[0048]

1. A thin-film deposition apparatus comprising:

a vacuum-tight deposition chamber enclosing a substrate holding device for holding a substrate;

an elevator device to raise or lower said substrate holding device between a deposition position and a transport position;

a gas showering head for flowing a film forming gas towards said substrate;

a transport opening provided on a wall section of said deposition chamber at a height to correspond to said transport position; and

an exhaust opening provided on said wall section at a height between said deposition position and said transport position,

wherein said deposition chamber is provided with a flow guiding member, said flow guiding member comprising a cylindrical member to surround an elevating path of said substrate holding device, and a first ring member to vertically divide a chamber space at a height between said exhaust opening and said transport opening.

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2. An apparatus wherein said flow guiding member is formed to define an annular flow path to guide a spent gas to said exhaust gas opening.

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3. An apparatus wherein said deposition chamber has substantially one exhaust opening.

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4. An apparatus wherein said apparatus is further provided with a second ring member disposed above said first ring member and covering said annular flow path so as to form a circumferential slit channel for communicating the chamber space with said annular flow path.

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5. An apparatus wherein said circumferential slit channel is shaped in such a way that a slit width in a vicinity of said exhaust opening is narrower than a slit width remote from said exhaust opening.

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6. An apparatus further comprising a flow adjusting

ring being placed on said second ring member so that a size of said circumferential slit channel can be adjusted to produce a uniform flow over said substrate.

7. An apparatus further comprising an outer flow guiding member disposed between the flow guiding member and an inner surface of said wall section to form an exhaust passage for a spent gas in association with the flow guiding member.

8. An apparatus further comprising a cylindrical wall member surrounding said substrate holding device, said flow guiding member being provided on an outer circumference of said cylindrical wall member.

9. An apparatus wherein said cylindrical wall member comprises an insulator member for suppressing radiation heat from said substrate holding device.

10. An apparatus wherein said cylindrical wall member is provided with a temperature control device to control said cylindrical wall member at a specific temperature.

11. An apparatus wherein said apparatus is provided with a cooling device to cool said wall section of said deposition temperature to a temperature lower than a predetermined temperature.

12. An apparatus wherein said flow guiding member is disposed in said deposition chamber in a detachable manner.

13. An apparatus wherein said cylindrical member and said first ring member are formed integrally.

14. A thin-film deposition apparatus comprising:

a cylindrical vacuum-tight deposition chamber enclosing a substrate holding/heating device; an elevator device to raise or lower said substrate holding/heating device between a deposition position and a transport position;

a gas showering head for flowing a film forming gas from a top of said deposition chamber towards said substrate;

a transport opening provided on a wall section of said deposition chamber at a height to correspond to said transport position; and

an exhaust opening provided on a wall section of said deposition chamber at a height between said deposition position and said transport position,

wherein a cylindrical thermal insulator member is disposed to surround said substrate holding/heating device placed at said deposi-

tion position.

15. An apparatus wherein said thermal insulator member is provided with a temperature control device for controlling said thermal insulator member at a predetermined temperature.

16. An apparatus wherein said thermal insulator member is disposed in said deposition chamber in a detachable manner.

17. An apparatus wherein said apparatus is provided with a cooling device to cool said wall section of said deposition chamber to a temperature lower than a predetermined temperature.

18. A thin-film deposition apparatus comprising:

a cylindrical vacuum-tight deposition chamber enclosing a substrate holding device for holding a substrate;

an elevator device to raise or lower said substrate holding device between a deposition position and a transport position;

a gas showering head having a nozzle plate for flowing a film forming gas from a top of said deposition chamber towards said substrate;

a transport opening provided on a wall section of said deposition chamber to correspond to a height of said transport position; and an exhaust opening provided on said wall section at a height between said deposition position and said transport position,

wherein said exhaust opening is formed substantially in one circumferential location, and a center of gas flow density of a gas flowing out of said gas showering head is offset from a center of said substrate held on said substrate holding device horizontally in a direction opposite to said exhaust opening.

19. An apparatus wherein a center of a nozzle region of said nozzle plate is offset from a center of said substrate held on said substrate holding device horizontally in a direction opposite to said exhaust opening.

20. An apparatus wherein said nozzle plate has a nozzle hole distribution where a larger number of nozzle holes are provided on the opposite side of said exhaust opening than the other.

21. An apparatus wherein said gas showering head is provided with a temperature control device for controlling said nozzle plate at a predetermined temperature by using a thermal medium.

22. An apparatus wherein said nozzle plate is pro-

vided with a nozzle area larger than said substrate.

### Claims

5 1. A thin-film deposition apparatus comprising:  
 a vacuum-tight deposition chamber enclosing a substrate holding device for holding a substrate;  
 an elevator device to raise or lower said substrate holding device between a deposition position and a transport position;  
 a gas showering head for flowing a film forming gas towards said substrate;  
 a transport opening provided on a wall section of said deposition chamber at a height to correspond to said transport position; and  
 an exhaust opening provided on said wall section at a height between said deposition position and said transport position,  
 wherein said deposition chamber is provided with a flow guiding member, said flow guiding member comprising a cylindrical member to surround an elevating path of said substrate holding device, and a first ring member to vertically divide a chamber space at a height between said exhaust opening and said transport opening.

20 30 2. An apparatus according to claim 1, wherein said flow guiding member is formed to define an annular flow path to guide a spent gas to said exhaust gas opening.

35 40 3. An apparatus according to claim 1, wherein said deposition chamber has substantially one exhaust opening.

45 40 4. An apparatus according to claim 2, wherein said apparatus is further provided with a second ring member disposed above said first ring member and covering said annular flow path so as to form a circumferential slit channel for communicating the chamber space with said annular flow path.

50 45 5. An apparatus according to any of the preceding claims, wherein said circumferential slit channel is shaped in such a way that a slit width in a vicinity of said exhaust opening is narrower than a slit width remote from said exhaust opening,  
 and/or further preferably comprising a flow adjusting ring being placed on said second ring member so that a size of said circumferential slit channel can be adjusted to produce a uniform flow over said substrate,  
 and/or further preferably comprising an outer flow guiding member disposed between the flow guiding member and an inner surface of said wall

section to form an exhaust passage for a spent gas in association with the flow guiding member, and/or further preferably comprising a cylindrical wall member surrounding said substrate holding device, said flow guiding member being provided on an outer circumference of said cylindrical wall member, and/or wherein preferably said cylindrical wall member comprises an insulator member for suppressing radiation heat from said substrate holding device, and/or wherein preferably said cylindrical wall member is provided with a temperature control device to control said cylindrical wall member at a specific temperature, and/or wherein preferably said apparatus is provided with a cooling device to cool said wall section of said deposition temperature to a temperature lower than a predetermined temperature, and/or wherein preferably said flow guiding member is disposed in said deposition chamber in a detachable manner, and/or wherein preferably said cylindrical member and said first ring member are formed integrally.

6. A thin-film deposition apparatus comprising:

a cylindrical vacuum-tight deposition chamber enclosing a substrate holding/heating device; an elevator device to raise or lower said substrate holding/heating device between a deposition position and a transport position; a gas showering head for flowing a film forming gas from a top of said deposition chamber towards said substrate; a transport opening provided on a wall section of said deposition chamber at a height to correspond to said transport position; and an exhaust opening provided on a wall section of said deposition chamber at a height between said deposition position and said transport position, wherein a cylindrical thermal insulator member is disposed to surround said substrate holding/heating device placed at said deposition position.

7. An apparatus according to any of the preceding claims wherein said thermal insulator member is provided with a temperature control device for controlling said thermal insulator member at a predetermined temperature, and/or wherein preferably said thermal insulator member is disposed in said deposition chamber in a detachable manner, and/or wherein preferably said apparatus is provided with a cooling device to cool said wall sec-

tion of said deposition chamber to a temperature lower than a predetermined temperature.

8. A thin-film deposition apparatus comprising:

a cylindrical vacuum-tight deposition chamber enclosing a substrate holding device for holding a substrate; an elevator device to raise or lower said substrate holding device between a deposition position and a transport position; a gas showering head having a nozzle plate for flowing a film forming gas from a top of said deposition chamber towards said substrate; a transport opening provided on a wall section of said deposition chamber to correspond to a height of said transport position; and an exhaust opening provided on said wall section at a height between said deposition position and said transport position, wherein said exhaust opening is formed substantially in one circumferential location, and a center of gas flow density of a gas flowing out of said gas showering head is offset from a center of said substrate held on said substrate holding device horizontally in a direction opposite to said exhaust opening.

9. An apparatus according to any of the preceding claims wherein a center of a nozzle region of said nozzle plate is offset from a center of said substrate held on said substrate holding device horizontally in a direction opposite to said exhaust opening, and/or wherein preferably said nozzle plate has a nozzle hole distribution where a larger number of nozzle holes are provided on the opposite side of said exhaust opening than the other, and/or wherein preferably said gas showering head is provided with a temperature control device for controlling said nozzle plate at a predetermined temperature by using a thermal medium, and/or wherein preferably said nozzle plate is provided with a nozzle area larger than said substrate.

10. A thin-film deposition apparatus comprising:

a vacuum-tight deposition chamber enclosing a substrate holding device for holding a substrate; an elevator device to raise or lower said substrate holding device between a deposition position and a transport position; and a gas showering head for flowing a film forming gas towards said substrate.

FIG. 1A

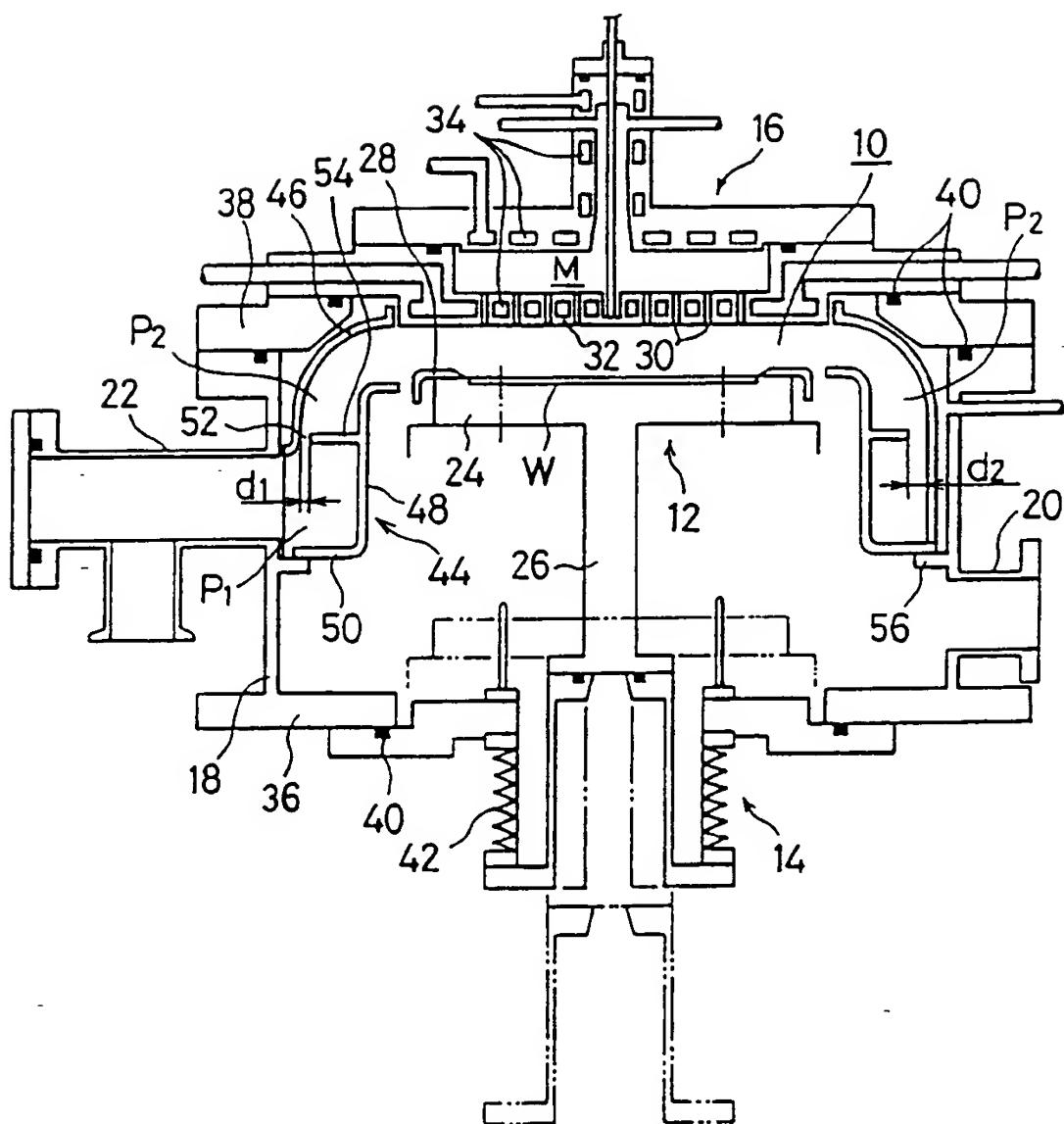
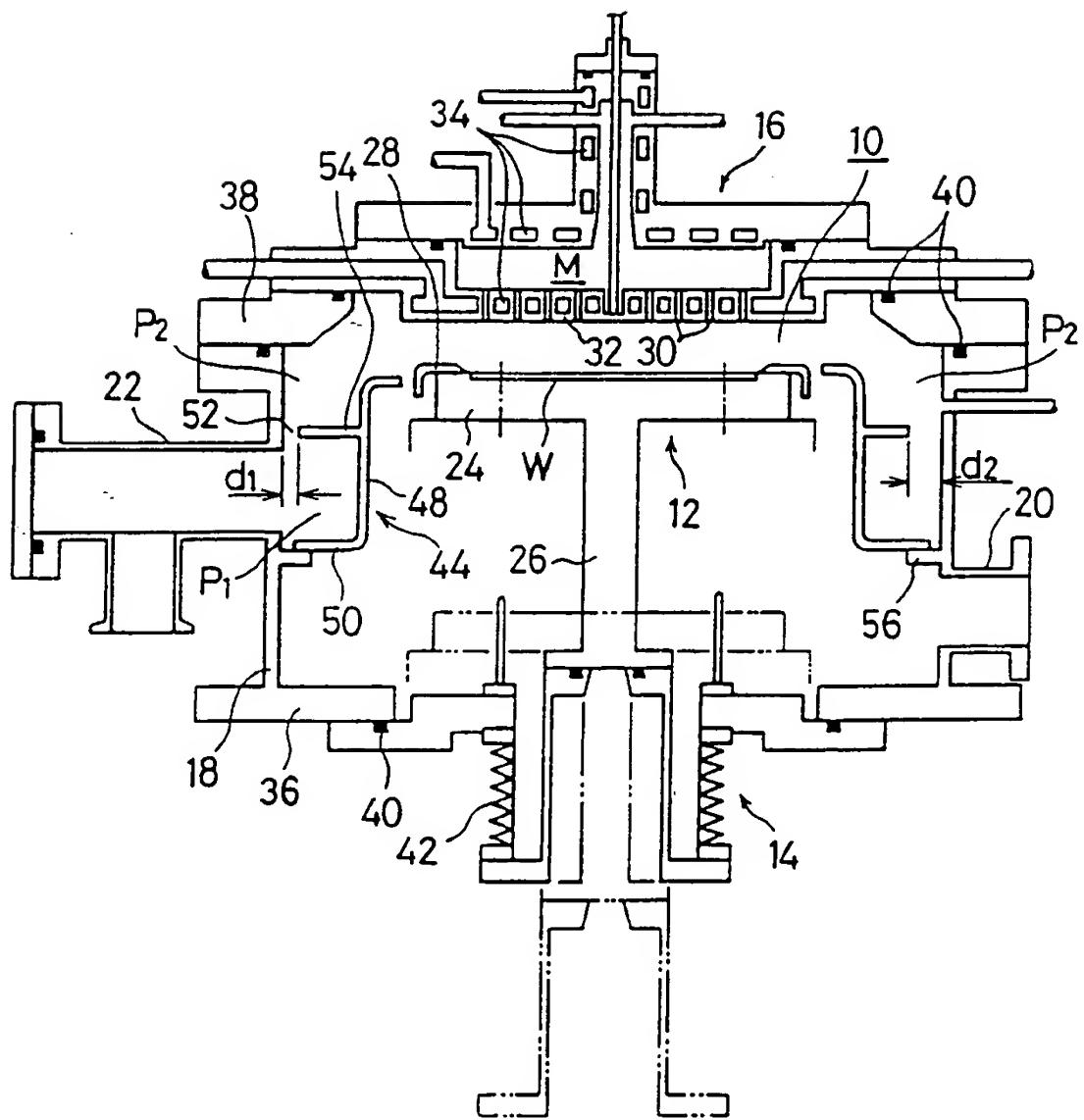
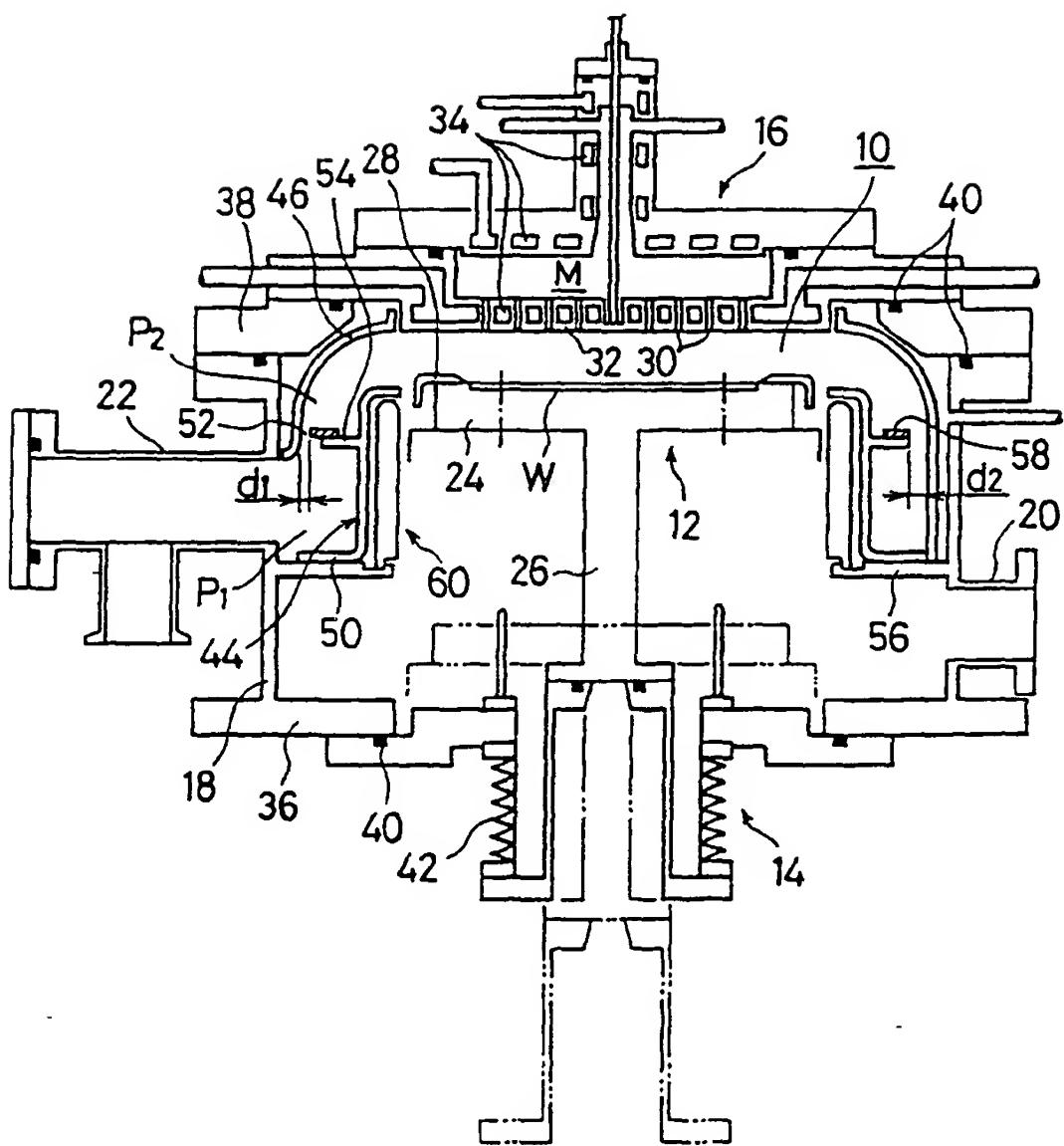


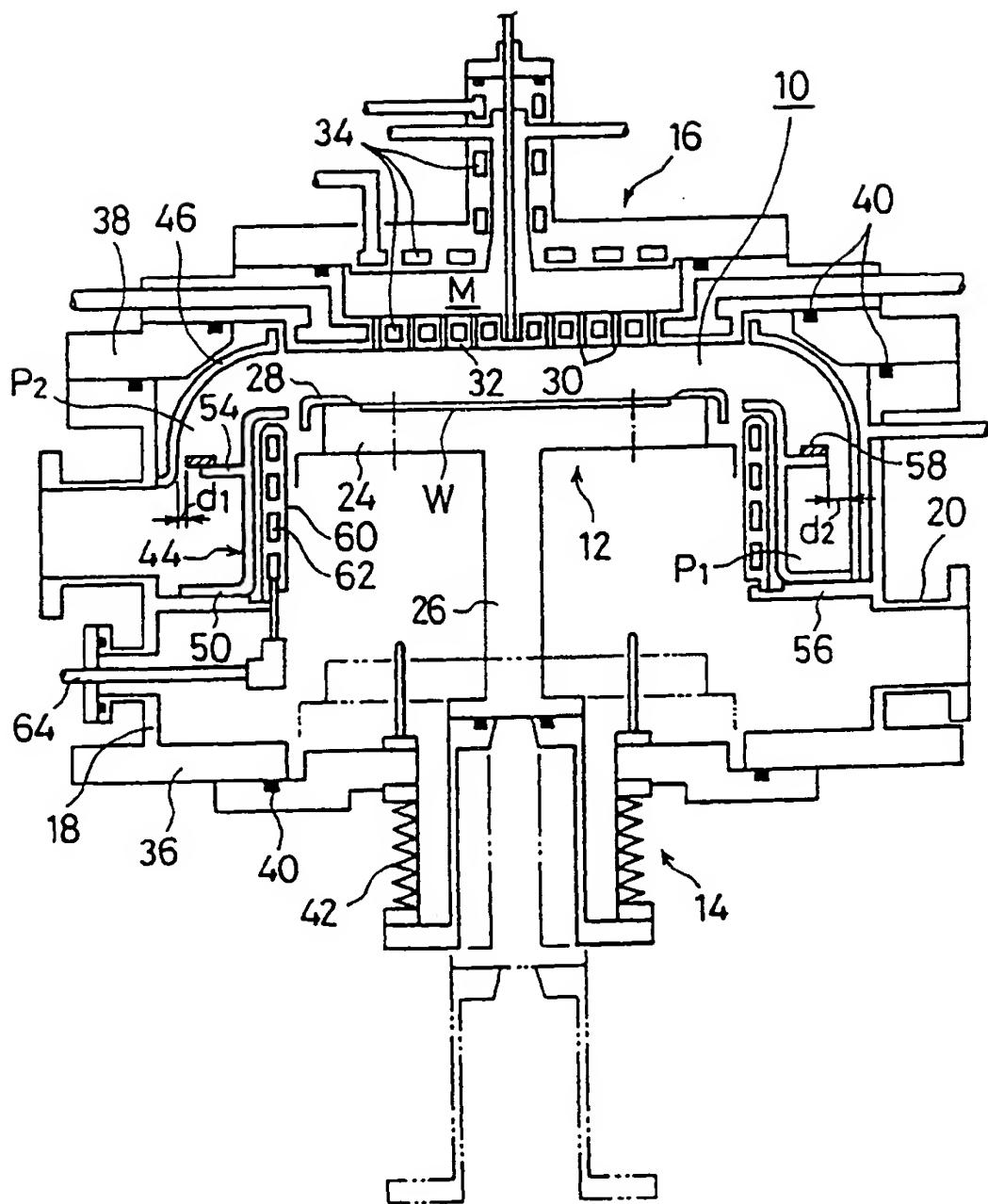
FIG. 1B



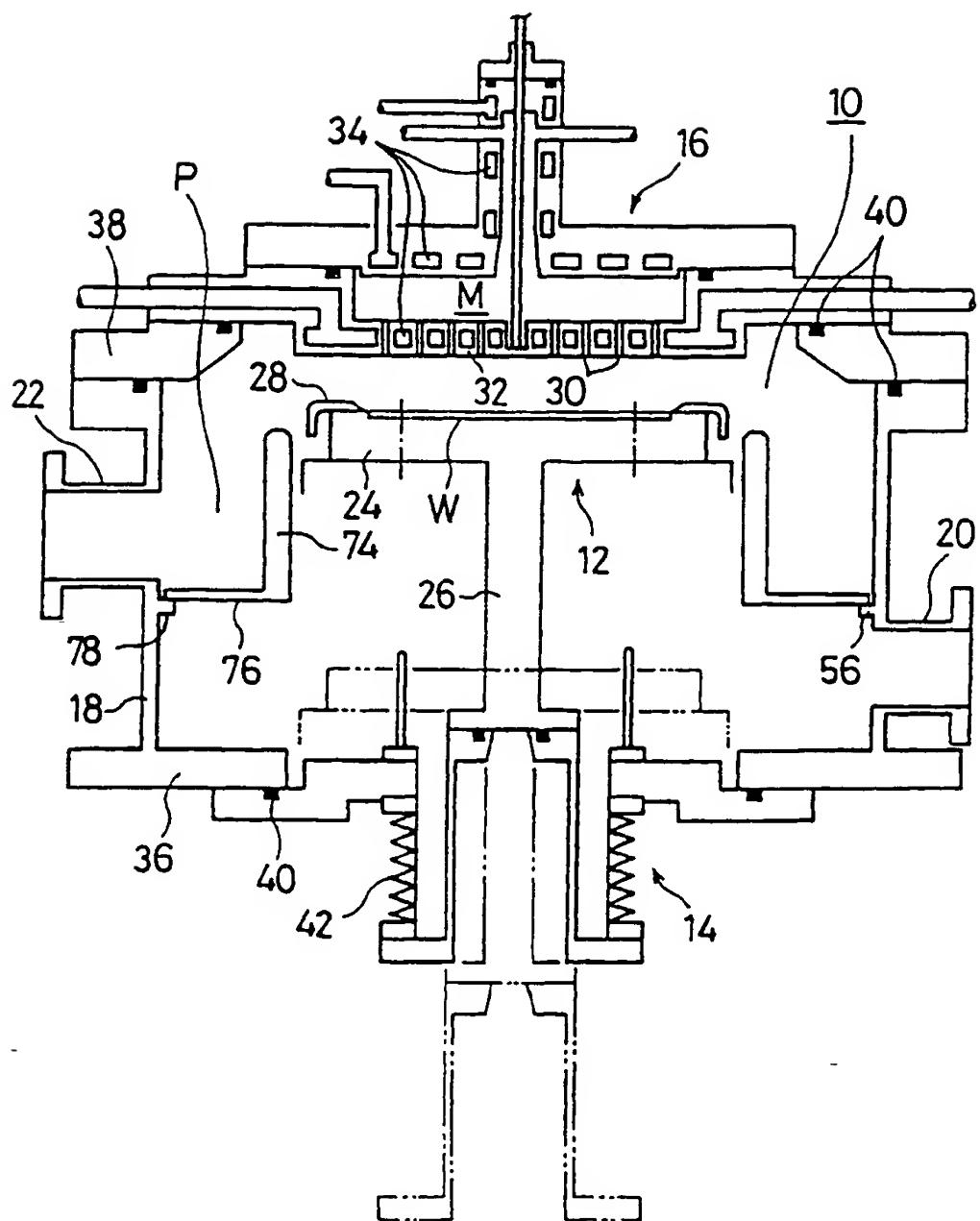
F / G. 2



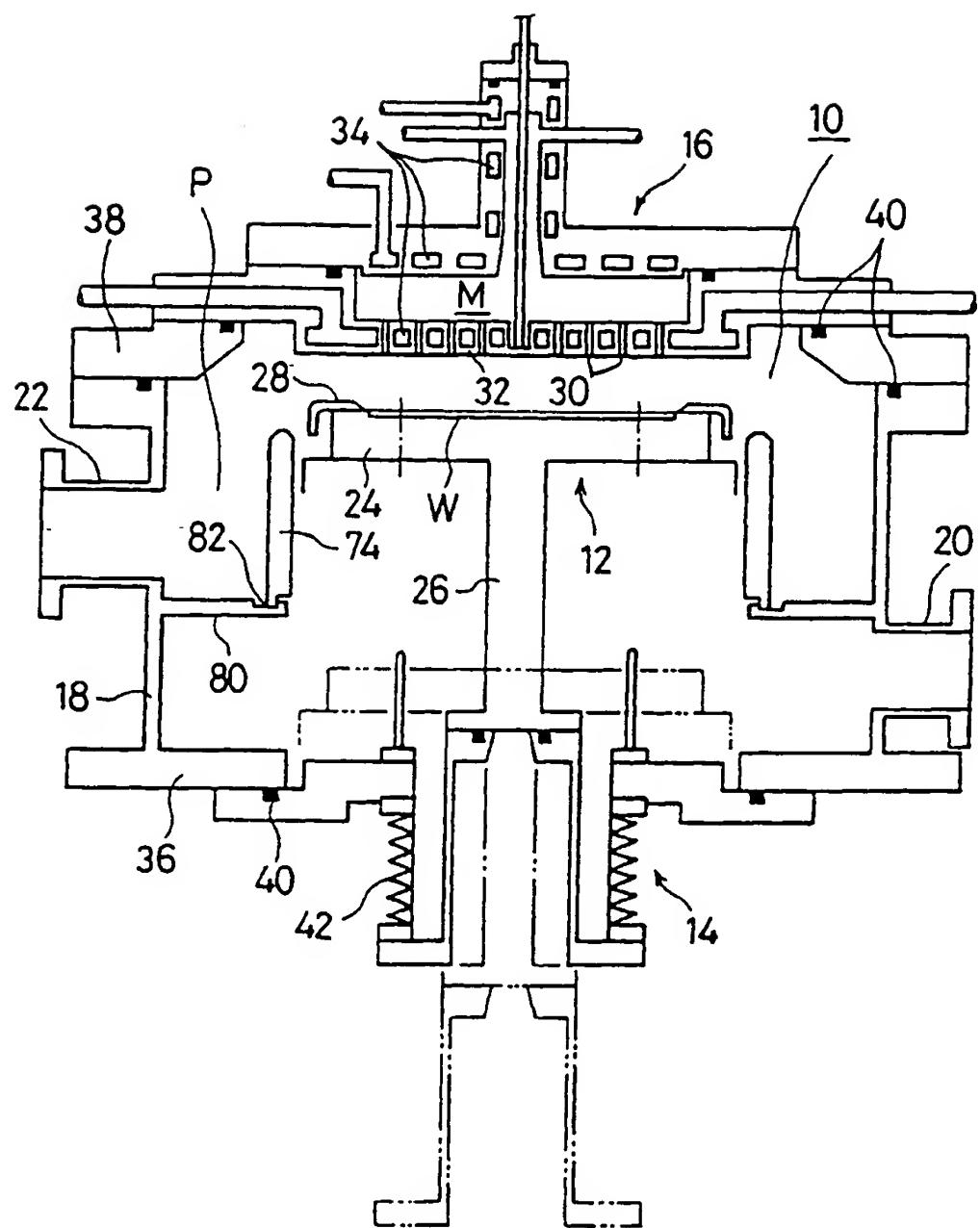
F / G. 3



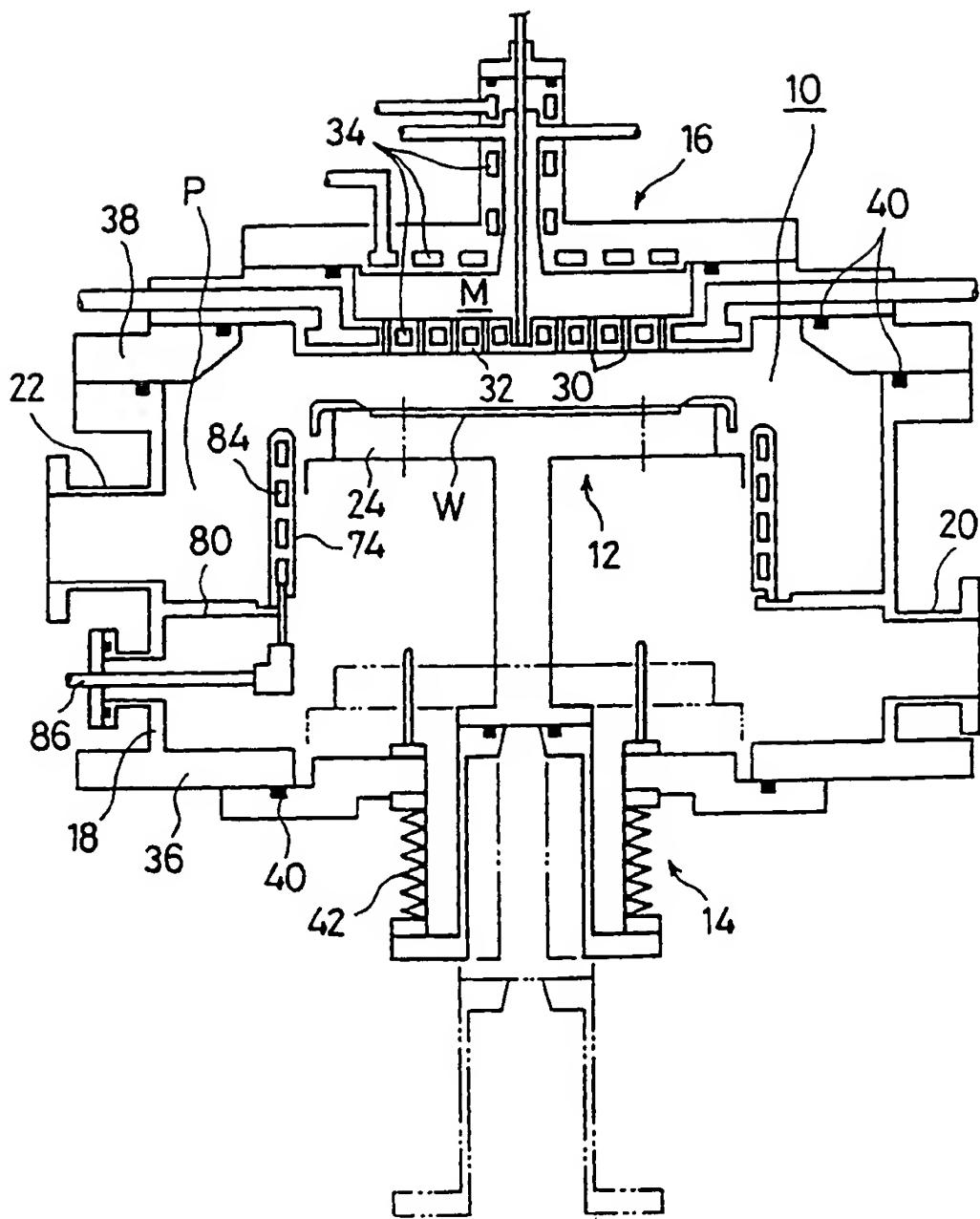
F / G. 4



F / G. 5



F / G. 6



*F / G. 7*

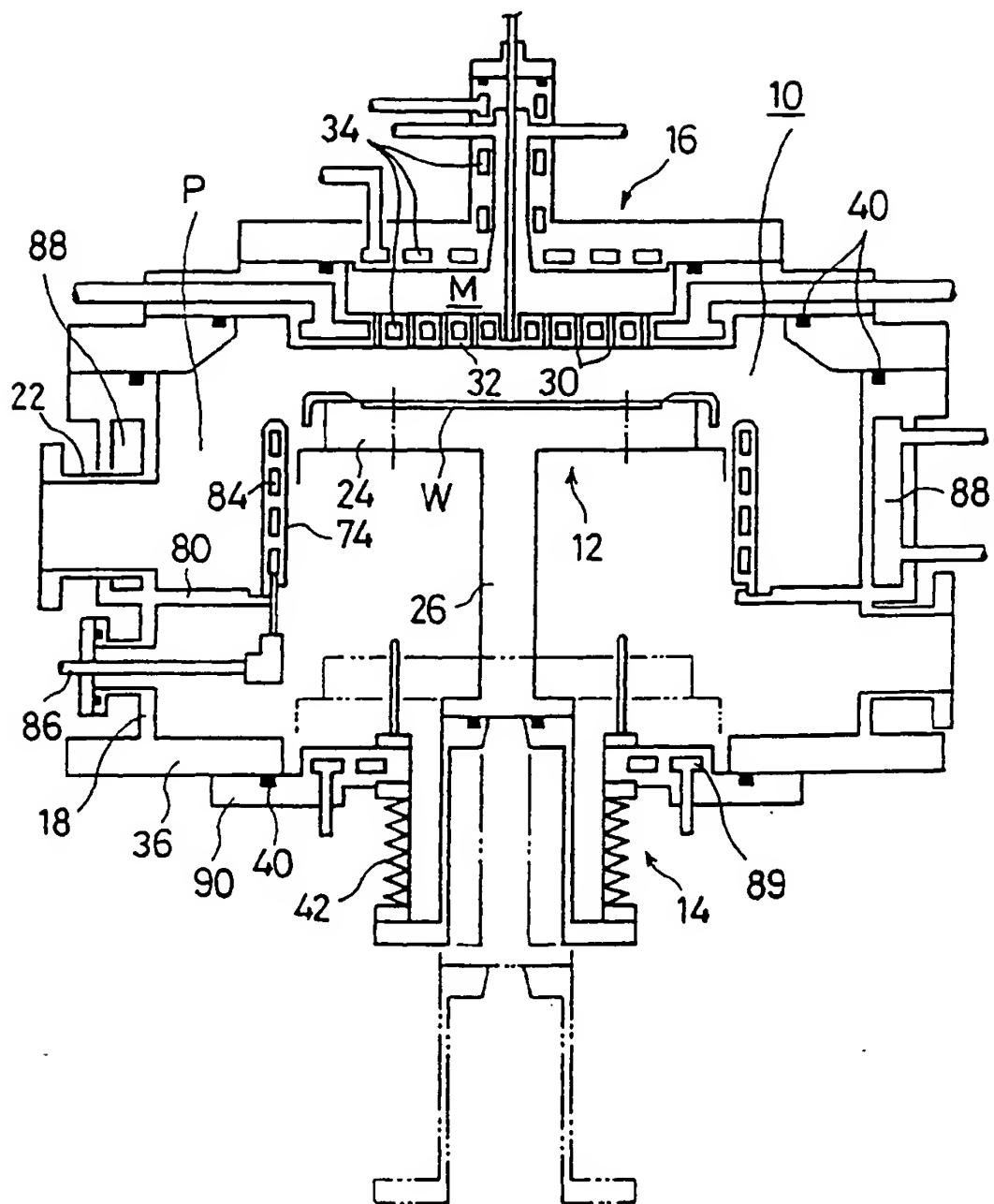
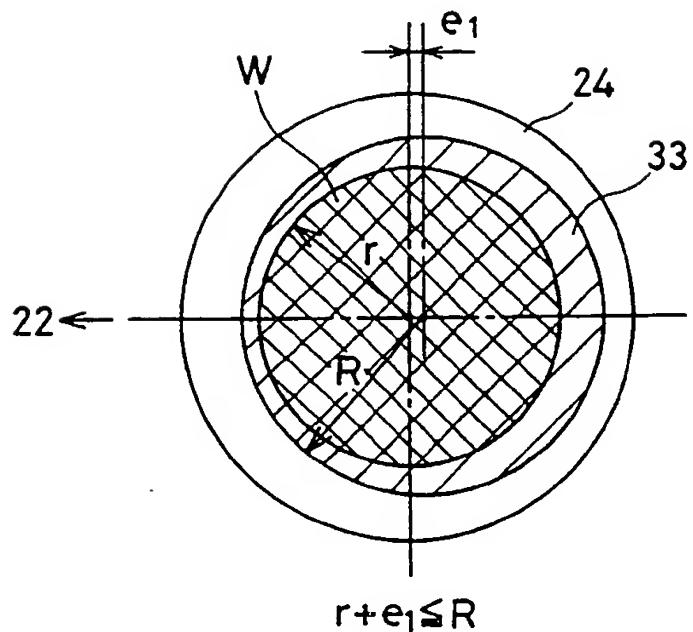


FIG. 8A



*F / G. 8 B*

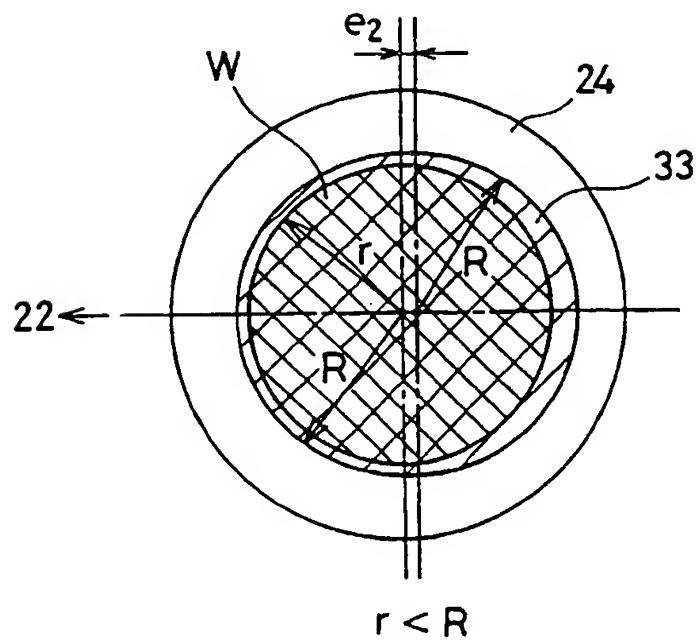


FIG. 9A

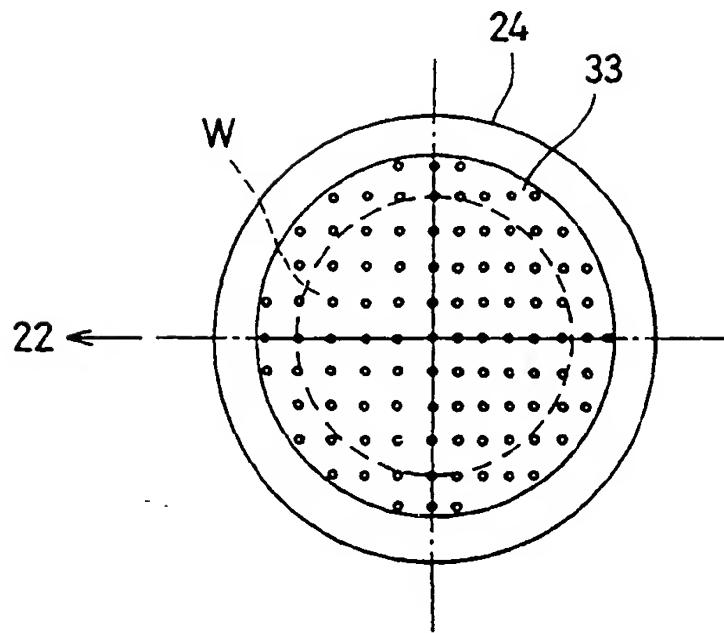
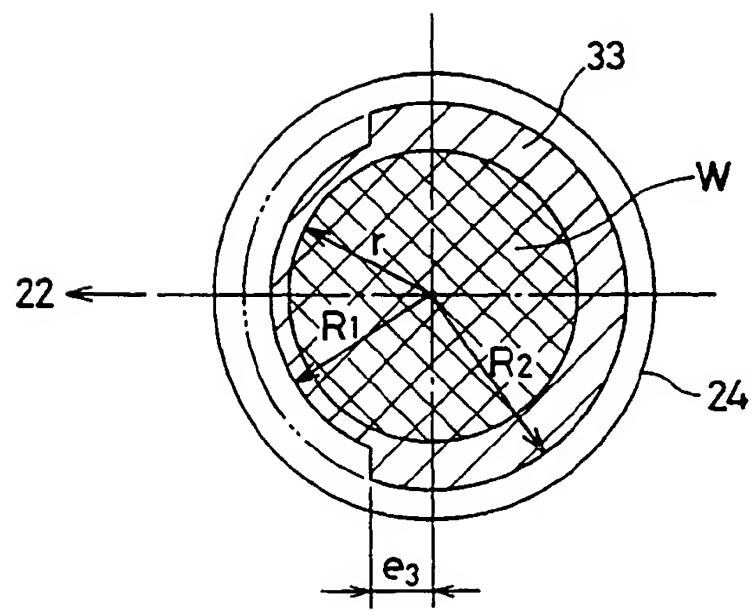
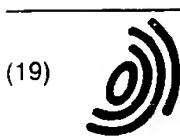


FIG. 9B





(19)

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(11)

EP 0 909 836 A3

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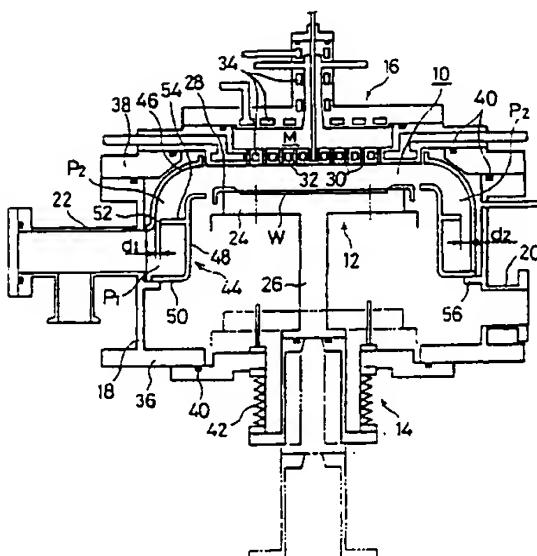
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## (54) Thin-film deposition apparatus

(57) A compact thin-film deposition apparatus can promote a stable growth of a high quality thin-film product of uniform quality. It comprises a vacuum-tight deposition chamber (10) enclosing a substrate holding device (12) for holding a substrate (W). An elevator device (14) for moving the substrate holding device and a gas showering head (16) for flowing a film forming gas towards the substrate are provided. A transport opening (20) and an exhaust opening (22) are provided on a wall section (18) of the deposition chamber at a height to correspond to the transport position and the deposition position respectively. The deposition chamber is provided with a flow guiding member (44), and the flow guiding member comprises a cylindrical member (48) to surround an elevating path of the substrate holding device and a first ring member (50) to vertically divide a chamber space at a height between the exhaust opening and the transport opening.

FIG. 1A





DOCUMENTS CONSIDERED TO BE RELEVANT					
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.8)		
X	EP 0 747 503 A (EBARA CORP) 11 December 1996 (1996-12-11)	6,7,9,10	C23C16/44 C23C16/54 C23C16/40		
Y	* figures 5,9 *	1-3,5,8			
A	* column 5, line 46 - column 6, line 14 * * column 7, line 45-51 * * column 9, line 14-48 * ---	1			
X	US 5 441 568 A (CHO TOM ET AL) 15 August 1995 (1995-08-15)	10			
Y	* figures 1,3 *	1-3,5			
A	* column 1, line 30 - column 2, line 13 * * column 3, line 40-59 * ---	4			
Y	US 5 552 017 A (YU CHEN-HUA ET AL) 3 September 1996 (1996-09-03) * abstract * * figures 4,5 *	8			
	-----				
			TECHNICAL FIELDS SEARCHED (Int.Cl.8)		
			C23C		
The present search report has been drawn up for all claims					
Place of search	Date of compilation of the search	Examiner			
THE HAGUE	25 April 2001	Castagné, C			
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Patent document cited in search report		Publication date		Patent family member(s)		Publication date
EP 0747503	A	11-12-1996		JP 8337876 A US 5728223 A		24-12-1996 17-03-1998
US 5441568	A	15-08-1995		JP 8064489 A KR 229704 B		08-03-1996 15-11-1999
US 5552017	A	03-09-1996		NONE		